55. ≈0.6435 radians or 36.8699°

56. ≈−1.1607 radians or −66.5014°

57. $\cos\theta = \frac{3}{7}$ $\quad \sin\theta = \frac{\sqrt{40}}{7}$ $\quad \tan\theta = \frac{\sqrt{40}}{3}$

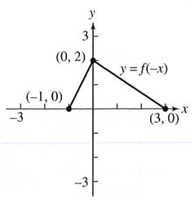
$\sec\theta = \frac{7}{3}$ $\quad \csc\theta = \frac{7}{\sqrt{40}}$ $\quad \cot\theta = \frac{3}{\sqrt{40}}$

58. (a) $x \approx 3.3430$ and $x \approx 6.0818$

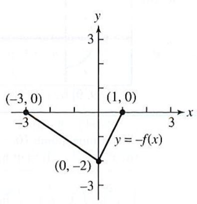
(b) $x \approx 3.3430 + 2k\pi$ and $x \approx 6.0818 + 2k\pi$, k any integer

59. $x = -5 \ln 4$

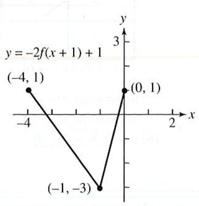
60. (a)



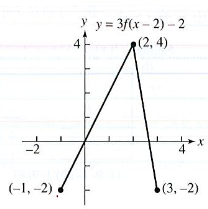
(b)



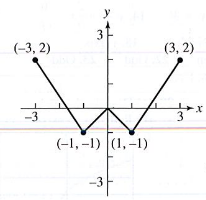
(c)



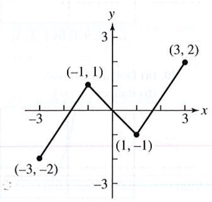
(d)



61. (a)



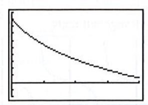
(b)



62. (a) $V = 100{,}000 - 10{,}000x$, $0 \le x \le 10$ **(b)** After 4.5 years

63. (a) 90 units **(b)** $90 - 52 \ln 3 \approx 32.8722$ units

(c)



[0, 4] by [−20, 100]

64. After $\frac{\ln(10/3)}{\ln 1.08} \approx 15.6439$ years

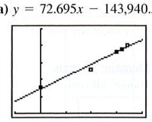
(If the bank only pays interest at the end of the year, it will take 16 years.)

65. (a) $N = 4 \cdot 2^t$ **(b)** 4 days: 64; 1 week: 512

(c) After $\frac{\ln 500}{\ln 2} \approx 8.9658$ days, or after nearly 9 days

(d) Because it suggests the number of guppies will continue to double indefinitely and become arbitrarily large, which is impossible due to the finite size of the tank and the oxygen supply in the water.

66. (a) $y = 72.695x - 143{,}940.564$

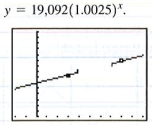


[−5, 20] by [0, 2500]

(b) 2103

(c) Slope = 72.695. It represents the number of doctoral degrees earned per year.

67. (a) $y = 19{,}092(1.0025)^x$.



[−2, 10] by [18500, 20000]

(b) 19,526 thousand or 19,526,000

(c) 0.0025 or 0.25%.

68. (a) $m = -1$ **(b)** $y = -x - 1$ **(c)** $y = x + 3$ **(d)** 2

69. (a) $(2, \infty)$ **(b)** $(-\infty, \infty)$ **(c)** $x = 2 + e \approx 4.718$

(d) $f^{-1}(x) = 2 + e^{1-x}$

(e)
$$\begin{aligned}(f \circ g^{-1})(x) = f(f^{-1}(x)) = f(2 + e^{1-x}) &= 1 - \ln(2 + e^{1-x} - 2)\\ &= 1 - \ln(e^{1-x})\\ &= 1 - (1 - x)\\ &= x\end{aligned}$$

$$\begin{aligned}(f^{-1} \circ g)(x) = f^{-1}(f(x)) = f^{-1}(1 - \ln(x-2)) &= 2 + e^{1-(1-\ln(x-2))}\\ &= 2 + e^{\ln(x-2)}\\ &= 2 + (x - 2)\\ &= x\end{aligned}$$

70. (a) $(-\infty, \infty)$ **(b)** $[-2, 4]$ **(c)** π **(d)** Even **(e)** $x \approx 2.526$

CHAPTER 2

Section 2.1

Quick Review 2.1

1. 0 **3.** 0 **5.** $-4 < x < 4$

7. $-1 < x < 5$ **9.** $x - 6$

Exercises 2.1

1. 48 ft/sec **3.** 96 ft/sec

5. $2c^3 - 3c^2 + c - 1$

7. $-\frac{3}{2}$ **9.** −15 **11.** 0 **13.** 4

15. (a)

x	−0.1	−0.01	−0.001	−0.0001
$f(x)$	1.566667	1.959697	1.995997	1.999600

(b)

x	0.1	0.01	0.001	0.0001
$f(x)$	2.372727	2.039703	2.003997	2.000400

The limit appears to be 2.

17. (a)

x	−0.1	−0.01	−0.001	−0.0001
$f(x)$	−0.054402	−0.005064	−0.000827	−0.000031

(b)

x	0.1	0.01	0.001	0.0001
$f(x)$	−0.054402	−0.005064	−0.000827	−0.000031

The limit appears to be 0.

19. (a)

x	−0.1	−0.01	−0.001	−0.0001
$f(x)$	2.0567	2.2763	2.2999	2.3023

(b)

x	0.1	0.01	0.001	0.0001
$f(x)$	2.5893	2.3293	2.3052	2.3029

The limit appears to be approximately 2.3.

21. Expression not defined at $x = -2$. There is no limit.

23. Expression not defined at $x = 0$. There is no limit.

25. $\frac{1}{2}$ **27.** $-\frac{1}{2}$ **29.** 12 **31.** −1 **33.** 0

35. Answers will vary. One possible graph is given by the window $[-4.7, 4.7]$ by $[-15, 15]$ with Xscl = 1 and Yscl = 5.

37. 0 **39.** 0 **41.** 1

43. (a) True **(b)** True

(c) False **(d)** True

(e) True **(f)** True

(g) False **(h)** False

(i) False **(j)** False

45. (a) 3 **(b)** −2

(c) No limit **(d)** 1

47. (a) −4 **(b)** −4

(c) −4 **(d)** −4

49. (a) 4 **(b)** −3

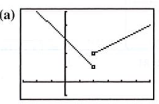
(c) No limit **(d)** 4

51. (c) **53.** (d)

55. (a) 6 **(b)** 0

(c) 9 **(d)** −3

57. (a)

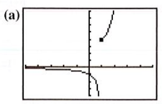


[−3, 6] by [−1, 5]

(b) Right-hand: 2 Left-hand: 1

(c) No, because the two one-sided limits are different

59. (a)

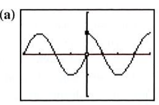


[−5, 5] by [−4, 8]

(b) Right-hand: 4 Left-hand: no limit

(c) No, because the left-hand limit doesn't exist

61. (a)

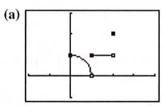


[−2π, 2π] by [−2, 2]

(b) $(-2\pi, 0) \cup (0, 2\pi)$

(c) $c = 2\pi$ **(d)** $c = -2\pi$

63. (a)



[−2, 4] by [−1, 3]

(b) $(0, 1) \cup (1, 2)$ **(c)** $c = 2$

(d) $c = 0$

65. 0

67. 0

69. (a) 14.7 m/sec

(b) 29.4 m/sec

71. True. Definition of limit.

73. C **75.** E

77. (a) Because the right-hand limit at zero depends only on the values of the function for positive x-values near zero

(b) Use: area of triangle $= \left(\frac{1}{2}\right)$(base)(height)

area of circular sector $= \frac{(\text{angle})(\text{radius})^2}{2}$

(c) This is how the areas of the three regions compare.

(d) Multiply by 2 and divide by $\sin\theta$.

(e) Take reciprocals, remembering that all of the values involved are positive.

(f) The limits for $\cos\theta$ and 1 are both equal to 1. Since $\frac{\sin\theta}{\theta}$ is between them, it must also have a limit of 1.

(g) $\dfrac{\sin(-\theta)}{-\theta} = \dfrac{-\sin(\theta)}{-\theta} = \dfrac{\sin(\theta)}{\theta}$

(h) If the function is symmetric about the y-axis, and the right-hand limit at zero is 1, then the left-hand limit at zero must also be 1.

(i) The two one-sided limits both exist and are equal to 1.

79. (a) $f\left(\dfrac{\pi}{6}\right) = \dfrac{1}{2}$

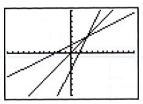
(b) One possible answer: $a = 0.305$, $b = 0.775$

(c) One possible answer: $a = 0.513$, $b = 0.535$

Section 2.2

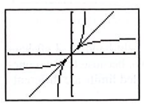
Quick Review 2.2

1. $f^{-1}(x) = \dfrac{x+3}{2}$



[-12, 12] by [-8, 8]

3. $f^{-1}(x) = \tan(x), -\dfrac{\pi}{2} < x < \dfrac{\pi}{2}$



[-6, 6] by [-4, 4]

5. $q(x) = \dfrac{2}{3}$

$r(x) = -3x^2 - \left(\dfrac{5}{3}\right)x + \dfrac{7}{3}$

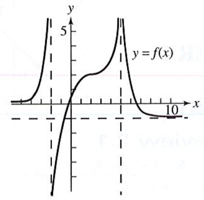
7. (a) $f(-x) = \cos x$ **(b)** $f\left(\dfrac{1}{x}\right) = \cos\left(\dfrac{1}{x}\right)$

9. (a) $f(-x) = -\dfrac{\ln(-x)}{x}$ **(b)** $f\left(\dfrac{1}{x}\right) = -x\ln x$

Exercises 2.2

1. (a) 1 **(b)** 1 **(c)** $y = 1$
3. (a) 0 **(b)** $-\infty$ **(c)** $y = 0$
5. (a) 3 **(b)** -3 **(c)** $y = 3, y = -3$
7. (a) 1 **(b)** -1 **(c)** $y = 1, y = -1$
9. 0 **11.** 0
13. ∞ **15.** $-\infty$ **17.** 0 **19.** ∞ **21.** Both are 1.
23. Both are 1. **25.** Both are 0.
27. (a) $x = -2, x = 2$
(b) Left-hand limit at -2 is ∞.
Right-hand limit at -2 is $-\infty$.
Left-hand limit at 2 is $-\infty$.
Right-hand limit at 2 is ∞.
29. (a) $x = -1$
(b) Left-hand limit at -1 is $-\infty$.
Right-hand limit at -1 is ∞.
31. (a) $x = k\pi$, k any integer
(b) At each vertical asymptote:
Left-hand limit is $-\infty$.
Right-hand limit is ∞.

33. Vertical asymptotes at $a = (4k+1)\dfrac{\pi}{2}$ and $b = (4k+3)\dfrac{\pi}{2}$, k any integer.
$\lim_{x\to a^-} f(x) = \infty$, $\lim_{x\to a^+} f(x) = -\infty$, $\lim_{x\to b^-} f(x) = -\infty$, $\lim_{x\to b^+} f(x) = \infty$
35. (a) **37.** (d)
39. (a) $3x^2$ **(b)** None
41. (a) $\dfrac{1}{2x}$ **(b)** $y = 0$
43. (a) $4x^2$ **(b)** None
45. (a) e^x **(b)** $-2x$
47. (a) x **(b)** x
49. At ∞: ∞ At $-\infty$: 0
51. At ∞: 0 At $-\infty$: 0
53. (a) 0 **(b)** -1 **(c)** $-\infty$ **(d)** -1
55. One possible answer:



57. $\dfrac{f_1(x)/f_2(x)}{g_1(x)/g_2(x)} = \dfrac{f_1(x)/g_1(x)}{f_2(x)/g_2(x)}$. As x goes to infinity, $\dfrac{f_1}{g_1}$ and $\dfrac{f_2}{g_2}$ both approach 1. Therefore, using the above equation, $\dfrac{f_1/f_2}{g_1/g_2}$ must also approach 1.

59. True. For example, $f(x) = \dfrac{x}{\sqrt{x^2+1}}$ has $y = \pm 1$ as horizontal asymptotes.

61. A **63.** C
65. (a) $f \to -\infty$ as $x \to 0^-$, $f \to \infty$ as $x \to 0^-$, $g \to 0$, $fg \to 1$
(b) $f \to \infty$ as $x \to 0^-$, $f \to -\infty$ as $x \to 0^+$, $g \to 0$, $fg \to -8$
(c) $f \to -\infty$ as $x \to 2^-$, $f \to \infty$ as $x \to 2^+$, $g \to 0$, $fg \to 0$
(d) $x \to \infty$, $g \to 0$, $fg \to \infty$
(e) Nothing—you need more information to decide.

67. For $x > 0$, $0 < e^{-x} < 1$, so $0 < \dfrac{e^{-x}}{x} < \dfrac{1}{x}$.
Since both 0 and $\dfrac{1}{x}$ approach zero as $x \to \infty$, the Sandwich Theorem states that $\dfrac{e^{-x}}{x}$ must also approach zero.

69. Limit = 2, because $\dfrac{\ln x^2}{\ln x} = \dfrac{2\ln x}{\ln x} = 2$.

71. Limit = 1. Since $\ln(x+1) = \ln x\left(1 + \dfrac{1}{x}\right) = \ln x + \ln\left(1 + \dfrac{1}{x}\right)$,
$\dfrac{\ln(x+1)}{\ln x} = \dfrac{\ln x + \ln(1 + 1/x)}{\ln x} = 1 + \dfrac{\ln(1 + 1/x)}{\ln x}$. But as $x \to \infty$, $1 + \dfrac{1}{x}$ approaches 1, so $\ln\left(1 + \dfrac{1}{x}\right)$ approaches $\ln(1) = 0$.
Also, as $x \to \infty$, $\ln x$ approaches infinity. This means the second term above approaches 0 and the limit is 1.

Quick Quiz (Sections 2.1 and 2.2)

1. D
3. E

Section 2.3

Quick Review 2.3

1. 2
3. (a) 1 **(b)** 2 **(c)** No limit **(d)** 2
5. $g(x) = \sin x, x \ge 0$ $(f \circ g)(x) = \sin^2 x, x \ge 0$
7. $x = \dfrac{1}{2}, -5$ **9.** $x = 1$

Exercises 2.3

1. $x = -2$, infinite discontinuity
3. None
5. All points not in the domain, i.e., all $x < -3/2$
7. $x = 0$, jump discontinuity
9. $x = 0$, infinite discontinuity
11. (a) Yes **(b)** Yes **(c)** Yes **(d)** Yes
13. (a) No **(b)** No
15. 0
17. No, because the right-hand and left-hand limits are not the same at zero
19. (a) $x = 2$ **(b)** Not removable; the one-sided limits are different.
21. (a) $x = 1$ **(b)** Not removable; it's an infinite discontinuity.
23. (a) All points not in the domain along with $x = 0, 1$
(b) $x = 0$ is a removable discontinuity; assign $f(0) = 0$. $x = 1$ is not removable; the two-sided limits are different.
25. $y = x - 3$

27. $y = \begin{cases} \dfrac{\sin x}{x}, & x \ne 0 \\ 1, & x = 0 \end{cases}$

29. $y = \sqrt{x} + 2$

31. The domain of f is all real numbers $x \ne 3$. f is continuous at all those points, so f is a continuous function.

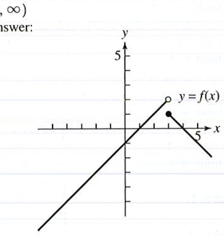
33. f is the composite of two continuous functions $g \circ h$ where $g(x) = \sqrt{x}$ and $h(x) = \dfrac{x}{x+1}$.

35. f is the composite of three continuous functions $g \circ h \circ k$ where $g(x) = \cos x$, $h(x) = \sqrt[3]{x}$, and $k(x) = 1 - x$.

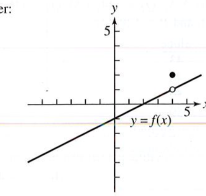
37. Assume $y = x$, constant functions, and the square root function are continuous.
Use the sum, composite, and quotient theorems.
Domain: $(-2, \infty)$

39. Assume $y = x$ and the absolute value function are continuous.
Use the product, constant multiple, difference, and composite theorems.
Domain: $(-\infty, \infty)$

41. One possible answer:



43. One possible answer:



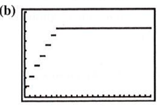
45. $x \approx -0.724$ and $x \approx 1.221$

47. $a = \dfrac{4}{3}$ **49.** $a = 4$

51. Consider $f(x) = x - e^{-x}$. f is continuous, $f(0) = -1$, and $f(1) = 1 - \dfrac{1}{e} > 0.5$. By the Intermediate Value Theorem, for some c in $(0, 1)$, $f(c) = 0$ and $e^{-c} = c$.

53. (a) $f(x) = \begin{cases} -1.10\,\text{int}(-x), & 0 \le x \le 6 \\ 7.25, & 6 < x \le 24 \end{cases}$

(b)



[0, 24] by [0, 9]

This is continuous at all values of x in the domain $[0, 24]$ except for $x = 0, 1, 2, 3, 4, 5, 6$.

55. False. If f has a jump discontinuity at $x = a$, then $\lim_{x\to a^-} f(x) \ne \lim_{x\to a} f(x)$ so f is not continuous at $x = a$.
57. E **59.** E
61. This is because $\lim_{h\to 0} f(a+h) = \lim_{x\to a} f(x)$.
63. Since the absolute value function is continuous, this follows from the theorem about continuity of composite functions.

Section 2.4

Quick Review 2.4

1. $\Delta x = 8$, $\Delta y = 3$
3. Slope $= -\dfrac{4}{7}$
5. $y = \dfrac{3}{2}x + 6$
7. $y = -\dfrac{3}{4}x + \dfrac{19}{4}$
9. $y = \dfrac{2}{-3}x + \dfrac{7}{3}$

Exercises 2.4

1. (a) 19 **(b)** 1
3. (a) $\dfrac{1 - e^{-2}}{2} \approx 0.432$ **(b)** $\dfrac{e^3 - e}{2} \approx 8.684$
5. (a) $-\dfrac{4}{\pi} \approx -1.273$ **(b)** $-\dfrac{3\sqrt{3}}{\pi} \approx -1.654$

7. Using $Q_1 = (10, 225)$, $Q_2 = (14, 375)$, $Q_3 = (16.5, 475)$, $Q_4 = (18, 550)$, and $P = (20, 650)$

(a)

Secant	Slope
PQ_1	43
PQ_2	46
PQ_3	50
PQ_4	50

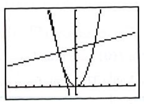
Units are meters/second

(b) Approximately 50 m/sec

9. (a) -4 **(b)** $y = -4x - 4$

(c) $y = \frac{1}{4}x + \frac{9}{2}$

(d)

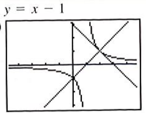


[−8, 7] by [−1, 9]

11. (a) -1 **(b)** $y = -x + 3$

(c) $y = x - 1$

(d)



[−4.7, 4.7] by [−3.1, 3.1]

13. (a) 1 **(b)** -1

15. No. Slope from the left is -2; slope from the right is 2. The two-sided limit of the difference quotient doesn't exist.

17. Yes. The slope is $-\frac{1}{4}$.

19. (a) $2a$ **(b)** The slope of the tangent steadily increases as a increases.

21. (a) $-\frac{1}{(a-1)^2}$

(b) The slope of the tangent is always negative. The tangents are very steep near $x = 1$ and nearly horizontal as a moves away from the origin.

23. 3 ft/sec **25.** $-1/4$ ft/sec **27.** 19.6 m/sec

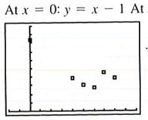
29. 6π in^2/in. **31.** 3.72 m/sec

33. $(-2, -5)$

35. (a) At $x = 0$: $y = -x - 1$
At $x = 2$: $y = -x + 3$

(b) At $x = 0$: $y = x - 1$ At $x = 2$: $y = x - 1$

37. (a)



[−2, 10] by [0, 1000]

(b) Slope of $PQ_1 = 2$, slope of $PQ_2 = 25.33$, slope of $PQ_3 = -59$.

39. True. The normal line is perpendicular to the tangent line at the point.

41. D **43.** C

45. (a) $\frac{e^{1+h} - e}{h}$ **(b)** Limit ≈ 2.718 **(c)** They're about the same.

(d) Yes, it has a tangent whose slope is about e.

47. No **49.** Yes

51. This function has a tangent with slope zero at the origin. It is sandwiched between two functions, $y = x^2$ and $y = -x^2$, both of which have slope zero at the origin.

Looking at the difference quotient, $-h \le \frac{f(0+h) - f(0)}{h} \le h$, so the Sandwich Theorem tells us that the limit is 0.

53. Slope ≈ 0.540

55. If $x = a + h$, then $x - a = h$. Replacing $f(a + h)$ by $f(x)$ and h by $x - a$ turns the first expression given for the difference quotient into the second expression.

Quick Quiz (Sections 2.3 and 2.4)

1. D **3.** B

Review Exercises

1. -15 **2.** $\frac{5}{21}$

3. No limit **4.** No limit

5. $-\frac{1}{4}$ **6.** $\frac{2}{5}$

7. $+\infty, -\infty$ **8.** $\frac{1}{2}$

9. 2 **10.** 0 **11.** 6 **12.** 5

13. 0 **14.** 1 **15.** Limit exists

16. Limit exists **17.** Limit exists

18. Doesn't exist **19.** Limit exists

20. Limit exists

21. Yes **22.** No

23. No **24.** Yes

25. (a) 1 **(b)** 1.5 **(c)** No

(d) g is discontinuous at $x = 3$ (and points not in domain).

(e) Yes, can remove discontinuity at $x = 3$ by assigning the value 1 to $g(3)$.

26. (a) 1.5 **(b)** 0 **(c)** 0 **(d)** No

(e) k is discontinuous at $x = 1$ (and points not in domain).

(f) Discontinuity at $x = 1$ is not removable because the two one-sided limits are different.

27. (a) Vertical Asymp.: $x = -2$

(b) Left-hand limit $= -\infty$
Right-hand limit $= \infty$

28. (a) Vertical Asymp.: $x = 0$ and $x = -2$

(b) At $x = 0$:
Left-hand limit $= -\infty$
Right-hand limit $= -\infty$
At $x = -2$:
Left-hand limit $= -\infty$
Right-hand limit $= -\infty$

29. (a) At $x = -1$:
Left-hand limit $= 1$
Right-hand limit $= 1$
At $x = 0$:
Left-hand limit $= 0$
Right-hand limit $= 0$
At $x = 1$:
Left-hand limit $= -1$
Right-hand limit $= 1$

(b) At $x = -1$:
Yes, the limit is 1.
At $x = 0$:
Yes, the limit is 0.
At $x = 1$:
No, the limit doesn't exist because the two one-sided limits are different.

(c) At $x = -1$:
Continuous because $f(-1) =$ the limit.
At $x = 0$:
Discontinuous because $f(0) \ne$ the limit.
At $x = 1$:
Discontinuous because limit doesn't exist.

30. (a) Left-hand limit $= 3$ Right-hand limit $= -3$

(b) No, because the two one-sided limits are different

(c) Every place except for $x = 1$

(d) At $x = 1$

31. $x = -2$ and $x = 2$

32. There are no points of discontinuity.

33. (a) $2/x$ **(b)** $y = 0$ (x-axis)

34. (a) 2 **(b)** $y = 2$

35. (a) x^2 **(b)** None

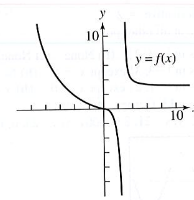
36. (a) x **(b)** None

37. (a) e^x **(b)** x

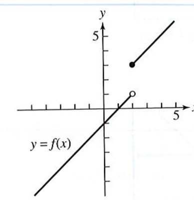
38. (a) $\ln|x|$ **(b)** $\ln|x|$

39. $k = 8$ **40.** $k = \frac{1}{2}$

41. One possible answer:



42. One possible answer:



43. $\frac{2}{\pi}$ **44.** $\frac{2}{3}\pi aH$ **45.** $12a$ **46.** $2a - 1$

47. (a) -1 **(b)** $y = -x - 1$ **(c)** $y = x - 3$

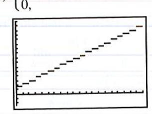
48. $\left(\frac{3}{2}, -\frac{9}{4}\right)$

49. (a) Perhaps this is the number of bears placed in the reserve when it was established.

(b) 200

49. (c) Perhaps this is the maximum number of bears that the reserve can support due to limitations of food, space, or other resources. Or, perhaps the number is capped at 200 and excess bears are moved to other locations.

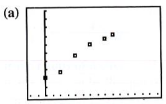
50. (a) $\begin{cases} f(x)3.20 - 1.35 \cdot \text{int}(-x + 1), & 0 < x \le 20 \\ 0, & x = 0 \end{cases}$



[0, 20] by [−5, 32]

(b) f is discontinuous at integer values of x: 0, 1, 2, . . . , 19

51. (a)



[−2, 15] by [15000, 20000]

(b) Slope of $PQ_1 = 313.857$; slope of $PQ_2 = 244.8$; slope of $PQ_3 = 210$

(c) Answers are the same as in part (b) but with *people per year* added.

(d) Answers will vary.

(e) Answers will vary.

52. $\lim_{x\to c} f(x) = 3/2$; $\lim_{x\to c} g(x) = 1/2$

53. (a) All real numbers except 3 or -3.

(b) $x = -3$ and $x = 3$ **(c)** $y = 0$

(d) Odd, because $f(-x) = \frac{-x}{|(-x)^2 - 9|} = -\frac{x}{|x^2 - 9|} = -f(x)$ for all x in the domain.

(e) $x = -3$ and $x = 3$. Both are nonremovable.

54. (a) $\lim_{x\to 2^-} f(x) = \lim_{x\to 2^-} (x^2 - a^2x) = 4 - 2a^2$.

(b) $\lim_{x\to 2^+} f(x) = \lim_{x\to 2^+} (4 - 2x^2) = -4$

(c) For $\lim_{x\to 2} f(x)$ to exist, we must have $4 - 2a^2 = -4$, so $a = \pm 2$. If $a = \pm 2$, then $\lim_{x\to 2^-} f(x) = \lim_{x\to 2^+} f(x) = f(2) = -4$, making f continuous at 2 by definition.

55. (a) The zeros of $f(x) = \frac{x^3 - 2x^2 + 1}{x^2 + 3}$ are the same as the zeros of the polynomial $x^3 - 2x^2 + 1$. By inspection, one such zero is $x = 1$. Divide $x^3 - 2x^2 + 1$ by $x - 1$ to get $x^2 - x - 1$, which has zeros $\frac{1 \pm \sqrt{5}}{2}$ by the quadratic formula. Thus, the zeros of f are 1, $\frac{1 + \sqrt{5}}{2}$, and $\frac{1 - \sqrt{5}}{2}$.

(c) $\lim_{x\to\infty} f(x) = +\infty$ and $\lim_{x\to\infty} \frac{f(x)}{g(x)} = \lim_{x\to\infty} \frac{x^3 - 2x^2 + 1}{x^3 + 3x} = 1$.

CHAPTER 3

Section 3.1

Quick Review 3.1

1. 4 **3.** -1 **5.** 0

7. $\lim_{x\to 1^+} f(x) = 0$; $\lim_{x\to 1^-} f(x) = 3$

9. No, the two one-sided limits are different.

Exercises 3.1

1. $-1/4$ **3.** 2 **5.** $-1/4$ **7.** $1/4$

9. $f'(x) = 3$ **11.** $2x$ **13. (b)** **15. (d)**

17. (a) $y = 5x - 7$ **(b)** $y = -\frac{1}{5}x + \frac{17}{5}$

19. (a) $y = 3x - 2$ **(b)** $y = -\frac{1}{3}x + \frac{4}{3}$

21. (a) Sometime around April 1. The rate then is approximately 1/6 hour per day.

(b) Yes. Jan. 1 and July 1

(c) Positive: Jan 1, through July 1 Negative: July 1 through Dec. 31